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June 1, 1956

TECHNIQUES FOR DETERMINING DESIRABLE RESIDENTIAL LOT SIZES

A THESIS

Presented to
the Faculty of the Graduate Division
Georgia Institute of Technology

In Partial Fulfillment
of the Requirements for the Degree
Master of City Planning

By
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June 1956

TECHNIQUES FOR DETERMINING DESIRABLE

RESIDENTIAL LOT SIZES

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Date Approved by Chairman: May 25, 1956

ACKNOWLEDGMENTS

If this thesis were dedicated to any person or persons, it would be to my wife, Mr. and Mrs. Sidney F. Thomas, Jr., and all the others who have given so freely of their time and talents in assisting me to write and present it. To dedicate the thesis, however, would require the listing of the names of all of the people who gave me assistance in any way. That would be impossible, because all of the taxpayers in the United States have made a real contribution. Without the financial assistance afforded me by the American people through the United States Veterans Administration educational program, I could not have attended college.

A special note of appreciation is due Misses Doris N. Isley and Martha Rand of the Architectural Library at The Georgia Institute of Technology for their invaluable assistance in library research.

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CHAPTER I

INTRODUCTION

When drafting subdivision regulations, city planners have always been confronted with the question of what is the optimum residential lot size and how may it best be determined. This thesis attempts to provide an answer to this question.

Purpose.--The purpose of this thesis is to establish a method for determining residential lot areas and dimensions which may be specified in land-subdivision regulations. The results of the method used here would not necessarily be minimum lot sizes, but would more accurately represent desirable residential lot sizes tailored to fit the particular situation existing in any community. Four types of residential lots are considered. Each one is based upon the number of dwelling units that the lot is to accommodate. These four types of lots include: (1) single-family lot--a lot containing a structure that accommodates one dwelling unit, (2) two-family lot--a lot containing a single structure that accommodates two dwelling units, either attached side-by-side or one above the other, (3) multi-family lot--a lot containing a single struc-that accommodates three or more dwelling units, and (4) group housing projects--a lot or parcel of land on which one-, two-, and multi-family structures, or any combination of these, may be built as a single enterprise or under single ownership. There are other possible classifications of residential lots, but these four include a major part of the residential development in the United States.

The scope of the thesis is limited to residential lots; no consideration is given to commercial or industrial lot sizes. Residential lot areas and dimensions that are best suited for each type of residential structure are given in the final chapter. These areas and dimensions are determined by methods which are applicable to any community. It is not expected that the areas and dimensions found here will prove applicable to all communities, nor even to cities of any particular size. The areas and dimensions recommended in this thesis are based partly on conditions existing in the Atlanta Metropolitan area. However, when it was not possible to find applicable figures, typical conditions were assumed and usable figures were determined that are based on these assumptions. The real and assumed figures are used to illustrate a method.

Problems.--The principal problem in establishing desirable residential lot sizes is not one that involves a scarcity of urban residential land, but one that is concerned with the cost, development, location, and the population density to be accommodated on such land. European societies have a land scarcity problem for urban expansion, but in America the problem is more one of determining how close to or how far from neighbors it is desirable for people to live on the abundance of available land. While the European must preserve every available foot of cultivable land, America is in the process of removing such land from production. At the same time, American cities are being depopulated because undesirably congested conditions exist. Inhabitants of the cities are finding it expedient to abandon their urban locations in favor of less congested areas, leaving their former urban residential areas to the use of people who are financially unable to leave the blighted areas, or who are willing to bear the burden of blight in return for convenience of location and sometimes lower rents. The crowded conditions that to a large extent cause the original resident to leave could have been prevented at the time the site was subdivided into residential lots. But based on tradition, lack of adequate transportation, and a lack of planning the land was platted into small, usually very narrow lots. The land became overpopulated to such an extent that privacy, light, air, sound insulation, and all of the amenities of comfortable and healthful living were gone. One of the purposes of planning is to prevent the development of such blighting conditions. One of the principal causes of blight is the small, narrow lot.

Minimum lot areas and dimensions have too often been accepted by land subdividers as a desirable standard rather than a standard below which development should not be permitted. Present public regulations are more often an expression of what existed in a community at the time the regulations were adopted than of what many of the people would prefer or require for healthful living. There is a need to look for a desirable or optimum standard of lot areas and dimensions, which may be incorporated into land-subdivision regulations.

Each community has a problem that is unique to its location, character, and the customs of its citizens. No community can classify its citizens into categories for which land area requirements may be determined. It was observed recently by a land subdivider in Winchester, Kentucky, that it was possible to determine land area requirements precisely for but one class of people; those who are dead. To determine desirable lot sizes it is necessary to identify those factors that affect areas and dimensions and evaluate their effect.

<u>General trend of lot widths and depths</u>.--In the past, transportation media have been influential in determining residential lot sizes in the United States. At the time of the settlement of the United States, practically all transportation was along streams by boat. The need at that time was for every residential lot to abut the stream for access to its transportation route. Streets and roads had little other than local significance. As a rule, the townsites were laid out in very narrow lots with excessive depths. The houses were designed to fit such lots. They were very long and

narrow with service areas at the rear. Normally there was a limited distance along any stream bank suitable for development. This made it essential that the available land be subdivided so as to accommodate the greatest number of persons. Many examples could be cited of this type of development, but Newport, Kentucky, located on the south side of the Ohio River, was built as a residential community to serve the industrial center across the river in Cincinnati, Ohio. A map of the city shows the original lots abutting the river with frontages of 25 feet and depths of from 300 to 600 feet. This area was built up originally with single-family houses of substantial construction. Many of them still are in use although they have been divided into multi-family dwellings. Such original platting poses a serious problem for the community today because these lots are too narrow for adequate housing. Only through clearance and redevelopment can they be made to meet reasonable health standards.

With the advent of horse-drawn carriages, residences were free from river front requirements, but lots were still required to be narrow so as to keep as many residences as possible near the center of the growing cities. Although the lots were not, in general, as deep as those in Newport, their widths remained substantially the same. The lot widths were, in effect, determined through the necessity of limiting travel-time to the center of the city. Today, many cities are paying exhorbitant prices in attempts to eliminate these substandard lots from their centers.

The period in which we are living has had its effect on lot widths in that increased use of the automobile has freed urban dwellers from living in the city in which they work. The distribution of people over a large area has made possible wider and shallower lots. Whereas the lots of the river-front period were 25 by 300 feet, present typical lots are 60 by 100 feet.

A second factor helping to bring about wider lots has been the tendency for single-family home builders to construct increasingly wider, shallower houses. The so-called "Ranch Type" house is three to six rooms wide, normally not more than two rooms in depth and one story high. The houses 25 to 50 years ago were from one to two rooms wide, three to six rooms deep, and from two to four stories high. The wide, shallow house of today has been referred to as being "The American's tendency towards bigness in appearance". Whatever the cause for the trend, it has had a desirable effect on lot sizes in that it has required wider lots.

Methodology.--The method that will be used to determine recommended lot areas and dimensions is an examination and evaluation of the factors that influence lot sizes. These factors are grouped under principal headings in Chapter Two. These factors include: topography, soil and soil formations, floor area per family, raw land cost, land preparation cost, structure foundation area, family outdoor activities; light, air, amenities, and sound insulation distances.

The first factors discussed are some considerations that affect all of the types of residential lots. The topography of land as it affects the required ratio of structure height to distance between structures, dwelling unit occupancy rates, and floor areas will be discussed in this section.

Another factor is the effect which the absence of public sewerage lines and water supply systems have on residential lot sizes. Suggested minimum lot sizes will be derived for the most common types of soils and soil conditions.

Land costs and the cost of providing the necessary land improvements and facilities to prepare a lot for residential building is the next factor to be examined and evaluated. This will be done by determining the cost of providing sewerage, drainage, public water, streets, curbs and gutters, sidewalks, and public recreation and school facilities to serve the residential lot. The cost of each of these utilities and facilities will be determined for 13 specific lot areas and the total cost of developing each of these 13 lot sizes will be found. The cost of developing residential lots of 13 sizes will be compared considering raw-land at various prices per acre.

The lot area occupied by the structures that will be accommodated on the four types of lots described on page one of this thesis is considered next. The foundation area of the structures will be determined on the basis of per-family floor area requirements, structure height in stories, and dwelling units per structure.

It is essential that residential lots provide for light, air, amenities, and sound insulation distance. The areas required for light, air, and amenities will be determined on the basis of acceptable standards of a light angle between the open sky and a horizontal plane through the window sill of windows on the first habitable floor of residential structures. Sound insulation distances will be determined in terms of front-, side-, and rear-yard requirements.

The final factor to be evaluated is space for outdoor activities. Activities which will be considered are those that require space on the residential lot for recreation, service, and gardening.

In Chapter Three the trends in residential lot areas and dimensions will be identified. A comparison will be made between the results of a study of subdivision regulations in effect in cities and urban counties in the United States that have been adopted since 1941 and the results of a similar study conducted by Mr. Harold W. Lautner of regulations adopted before 1941.[1] This comparison will indicate any trends in requirement for changes in residential lot areas, widths, and depths.

The trends identified will be further checked by an analysis of selected zoning ordinances that have been adopted since 1941 to determine residential lot areas and dimensions specified for medium density zones. Zoning ordinances will be reviewed from cities without regard to size. These cities include not more than three from any state, but at least one from every state of the United States. Since zoning ordinances are for the most part designed to control land-use in urban areas that have already been subdivided into residential lots, the areas and dimensions specified by these ordinances reflect more nearly the lot areas and dimensions that existed prior to the adoption of the ordinances than the present needs and wants of citizens of the community.

The findings and recommendations growing out of these studies are set forth in Chapter Four.

CHAPTER II

FACTORS AFFECTING LOT SIZES

It may be said that many city planning studies have the common purpose of finding ways to prevent or eliminate congestion of one kind or another. Traffic studies seek solutions to the problem of vehicular traffic congestion while housing and land-use studies seek solutions to the problem of population congestion. These studies which seek to relieve or prevent the latter type of congestion have two specific areas to investigate. These may be designated as being, first, too many dwelling units on a given area of land, and second, too many people living in any one dwelling unit. In order to prevent either, it is necessary for the public to control the number of dwellings per unit of land, and the number of persons per dwelling.

Mr. Harold Lautner defined a residential lot as " . . . a portion of a subdivision or other parcel of land intended for transfer of ownership or for building development".[2] He also indicated that the sizes and shapes of lots could not legally be directly controlled by public law, since the owner may convey as much or as little of his land as he wishes, even though the purchaser may be prevented from building upon what he bought.[3] This means that although there is no legal way to stop substandard parcels of land from being transferred, it is both possible and desirable to prevent their being used for building development when such development is contrary to the public interest.

Planning and public regulation of land used in crowded urban centers are established requisites to public health and safety. There is a real need for a greater measure of control than has been exercised in the past. Adequate lot areas and dimensions should be required and should be based on a sound analysis of all of the factors which affect residential lot size. These areas and dimensions should give an equality of open space to the inhabitants of all different types of dwelling accommodations. Topographic characteristics of lots and desirable floor area per family affect the desirable size of a residential lot. The effect that these two factors have is relatively constant in relation to the different lot types.

Topography

The lot area that is required for any type of residential accommodation will be affected by topography. A fixed rule of lot sizes cannot be applied to hilly land where building sites must be chosen with great care, and where soil conditions will affect the layout of the streets and utility lines.[4] Site planners set a limit of from 15 to 20 per cent grade for public streets in residential sections. Streets built on grades steeper than 15 per cent are more costly to maintain because of the eroding effect of surface water which destroys surfacing. Sanitary and storm drainage lines are eroded away in relatively short periods of time when they are installed with falls greater than four to six per cent. In order to install such utilities with acceptable slopes, the trenches must be dug deeper while manholes and catch-basins must be more elaborately constructed, all of which involve additional costs.

Whenever the cost of maintenance of streets and utilities is increased the tax load on real property is increased. The increased cost of installation of utilities and service facilities brought on by rough terrain adds to the cost of the residential lot. When costs are added to either the original lot or to continuing services for that lot, the developer will endeavor to reduce the amount of raw-land cost that he must invest in the development in an effort to reduce the cost of his product. Generally the only way that the developer can accomplish this reduction in raw-land cost is to reduce the area of the lot that he offers for sale.

Aside from the increased cost of facilities, roughness of the terrain will also have a direct effect on lot area requirements. It may be necessary to increase lot areas in hilly terrain in order to provide the same amount of effective usable space on the lot as would be afforded on a similar lot on level land. Work and play space on a residential lot must be relatively level before it is serviceable. Steep lots may have to be terraced to achieve sufficient level space for the structure, to facilitate access to the lot, and to provide space for parking, service, and play activities. Terracing reduces effective usable space for outdoor activities. Lot areas should be increased to compensate for the loss of effective space due to having to terrace rough land.

The steepness of land-grades will alter the relations of the height and spacing relationship of two structures erected on adjoining lots. Since the height of a structure is normally measured from the horizontal plane through its foundation, a structure on an elevated lot will cast a longer shadow on an adjoining lower lot than would be true if the same structures were erected side-by-side on level lots. Identical structures erected on adjoining lots that have a ten per cent grade would therefore need to be ten feet further apart per 100 lineal feet measured with the slope, for the lower structures to receive the same angle of light from the sky as the same structures would have if they were on level land. This indicates that there is a relation between lot widths and depths and the per cent slope of the land.

A slope map should be provided by the planning agency that can be included in the subdivision regulations. A customary topographical map is not sufficient. The map should show, by outline, the areas within given gradient limits such as, 0-5 per cent, 6-10 per cent, 11-15 per cent, and 16 per cent and over. In most locations these gradients will suffice.[5] A range of residential lot sizes based on the gradients could be specified for the areas outlined on the slope map.

Desirable Floor Area Per Dwelling Unit

Residential density involves people, structures, and land. It is necessary to determine the floor area per dwelling unit since it bears a relation to the foundation area required for dwelling structures. It has too often been the practice to subdivide land into lots and then attempt to fit a residential structure to the lot. To do so is to put the cart before the horse. Types of dwelling structures should be determined that are suitable for a particular family-size, and the optimum density that each area of the community can support, determined before lot sizes are specified for those areas. The population composition in terms of persons per family should be found for each community and provisions made to supply home sites that will accommodate those families. In 1950, 45 per cent of the national population was composed of families containing three and four persons; families of one and two persons made up 35 per cent, and those of five or more persons made up 20 per cent.[6] Dwelling units built for the family of three or four persons cannot adequately serve the family of five or more.[7] Housing should be provided in a close ratio to family composition that exists in each community. When current data concerning the family composition of the community and the number of houses needed to accommodate each type are made available, developers will have a better idea of the type of housing needed, and they are more likely to provide lot sizes to accommodate such facilities.

A method of approach to the problem of providing housing sites to conform to the family composition is to establish a gross floor area per room in dwellings (total dwelling-unit floor-area divided by the number of habitable rooms in the dwelling-units), and an occupancy rate per habitable room (persons per habitable room), and, based on these, determine a gross-floor-area per dwelling-unit.

A good index of congestion is the occupancy rate. The median occupancy rate in the United States urban population in 1950 was 0.68 for all occupied dwelling units, and 0.73 in rental occupied units. Most public housing units in New York City, however, have been 0.9 and 1.00 persons per room. The median is 0.93.[8] A rate of 0.9 person per room appears appropriate for all planning purposes, and will be used in this thesis for computations relating to density.

The gross-floor-area-per room in public housing units has ranged, on an average of, from 160 square feet in the early 1930's to 175 in the post World War II period.[9] Recommendations made by the American Public Health Association[10] relating to gross-floor-area-per-room, using the occupancy rate of 0.9 person per room, range from a minimum, for a one-person household, of 450 square feet; 390 square feet for the three-person family; and 342 square feet for the five-person family. The committee then states that: ". . . reasonable average gross floor space lies between 250 and 350 square feet."[11] These figures are approximately double the areas found in homes of the high income group,[12] and 25 per cent above areas now found in average public housing.[13] From these recommendations it is concluded that reasonable gross-floor-area-per-room for planning purposes is an average of 350 square feet.

The gross floor-areas-per-dwelling unit recommended by Emanuel for families ranging in size from one to six persons are shown in Table 1.[14]

Table 1. Floor Area Per Dwelling Unit As Recommended by Emanuel

No. Persons per Dwelling Unit	Recommended Floor Area per Dwelling Unit (sq. ft.)
1	500
2	1050
3	1300
4	1550
5	1900
6	2050

The areas in Table 1 were derived by Emanuel from the recommendations of APHA and the British Ministry of Health. They do not compare too closely with areas per dwelling unit calculated by the application of gross-floor-area-per-room to family sizes as given for families of from one to six persons in Table 2. The explanation appears to be that Emanual's recommendations are not necessarily minimum requirements, but areas which have been adjusted upward. The areas found by using the occupancy rate of 0.9 person per habitable room and 350 square feet gross area per habitable room result in the minimum per dwelling unit floor areas shown in Table 2.

Table 2. Gross Floor Area per Dwelling Unit Using 0.9 Person per Room and 350 Square Feet Gross-Floor-Area-per-Room

No. Persons per Dwelling Unit	Floor Area per Dwelling Unit (sq. ft.)
1	500
2	630
3	945
4	1260
5	1575
6	1890

Emanuel's recommendations appear higher than could reasonably be required. By interpolating his figures, the average United States family of 3.1 persons would require 1345 square feet of gross floor area. At an average cost of ten dollars per square feet of floor area the cost to build a house for the average family would be $13,450. Federal Housing Administration home financing regulations state that the average United States family, which had an annual income of $3,076 in 1950, could afford a house that costs not more than $9,600. This indicates that the average family could not afford housing if the floor area requirement were established at the figures given in Table 1. However, if the areas shown in Table 2 are used, the average family of 3.1 persons could afford a house of 976 square feet. At $10 per square foot, this house could be built for $9,760 which is quite close to the $9,600 that such a family can afford for a house.

In summary, it would appear reasonable to determine requirements for gross floor-area-per-dwelling unit based on Table 2. In order to do this it is necessary to make certain assumptions as to the gross floor-areas for the classes of dwelling units shown in Table 3 and relate them to family size. For the purpose of illustration the family size chosen will require the number of habitable rooms shown in the same table. The number of habitable rooms per dwelling unit was determined by assuming that a kitchen, a living room-dining room combination, and a sleeping room are the minimum number of habitable rooms that should be permitted. The so-called one-bedroom dwelling unit is the basic unit, and to accommodate families of larger sizes, bedrooms are added to this basic unit. The data given in Table 3 forms the basis for foundation area requirements set forth later in this chapter.

Table 3. Number of Habitable Rooms and Gross Floor Area per Dwelling Unit Required to Serve Various Family Sizes

No. of Persons per family	Class of Dwelling Unit	Number of Habitable Rooms per Dwelling Unit	Gross Floor Area per Dwelling Unit (sq. ft.)
2	1 bedroom	3	945
3	1 bedroom	3	945
4	2 bedroom	4	1260
5	3 bedroom	5	1575
6	4 bedroom	6	1890

Soil and Soil Formation

The nature and character of the soil are major factors to be taken into consideration in areas which are not or cannot be served by public water and sewerage systems. People involved in land-subdivision have too frequently discounted the importance of insuring safe sanitary drainage and water supply in rural and semi-rural developments. As pointed out by Robert C. Hoover, this is most often due to the fact that water and sewerage facilities are located underground, and the inadequacy of the sewerage disposal system is not discovered until sewage appears above the ground or typhoid fever breaks out in the community.[15] It is apparent that land areas which depend upon private sewerage and water systems must be planned with particular regard to the land's ability to accommodate habitation in a manner that conforms with the health standards of the community. The safety of private systems depends upon conditions of the soil and subsoil, location of rock strata, depth of hardpan, the porosity of the soil, height of the water table and other conditions of similar nature. Classifications of soil as established by the FHA and listed in descending order of suitability for private utility systems are:[16]

1. Clean coarse sand or gravel
2. Fine sand or light loam
3. Fine sand with some clay or loam
4. Clay with some sand or gravel
5. Heavy Clay
6. Heavy light clay, hardpan, rock or other impervious formation

The FHA and the New York State Department of Health agree that in soils of high gravel and sand content, private sewerage disposal systems work satisfactorily, but that extensive precautions and larger lots should be required where a layer of impervious hardpan or rock are near the surface.[17] Where slopes are gentle, a sewage system may be less costly than where grades are steep and the run off is swift. It is not uncommon to find an impervious layer of hardpan or bed rock where steeper grades are encountered.[18] Therefore, where steeper grades exist, special arrangements of distribution boxes to facilitate the slowing down of effluent may be necessary to preserve sanitary standards.

Most dwellings in open country can be served by flush toilets with septic tanks connected to a tile field or cesspool. It is important to know which of these is adaptable to the soil conditions and types of each situation. The space required for tile field facilities under tight soil conditions is considerable, and this fact should be taken into consideration in the establishment of minimum lot sizes set forth in land-subdivision regulations. One writer has established the following space requirements for tile field arrangements in various soil classifications:[19]

Nature of Soil	Minimum Distance between tile lines	Approximate length of 4" tile per person with effluent flow @ 50 g.p.d.
1. Clean course sand or gravel	6 feet	15 feet
2. Fine sand or light loams	6 feet	20 feet
3. Clay or loams	7.5 feet	30 feet
4. Clay with some gravel	9.0 feet	80 feet

A lot or subdivision located on a steep slope may require addition of distribution boxes, or other accommodations to gradient conditions that increase or even double the space needed for a tile field.[20]

Another requirement established by FHA is that no disposal field or cesspool shall come closer than 100 feet to the nearest private water supply on the same or any other lot.[21] It is necessary to determine whether or not there is sufficient soil filtration between the leaching area and water supply, and also whether the proposed tile field will drain toward a well or water supply. These matters cannot be controlled by public regulation alone. Decisions on these matters must be referred to qualified sanitary engineers instead of relying on the speculation of untrained individuals.[22]

It has been observed that gravelly or sandy soils may conduct sewage effluent to water sources without providing adequate filtration. This is particularly true where the land or substratum of rock or hardpan slopes toward the water source.[23]

Such circumstances will affect the size and shape of proposed lots. When public water supply is available the lot size can safely be scaled down since there is little danger of contamination, however, the requirement remains that the disposal area must be large enough to prevent effluent from appearing near the ground surface.[24]

In areas described as "heavy tight clay, hardpan, rock, or other impervious formations", it is doubtful that anything short of a public sewer connection or subsurface sand filter will be effective. However, the latter is difficult to maintain, expensive to operate, and must discharge into a flowing stream.[25] It would appear that the only solution in such areas would be for public regulations to be established requiring unusually large lot areas, or that residential development be prohibited until public facilities can be provided.

In-city densities are not safe in open-country areas where the normal sanitary facilities are not available. It is necessary to face the fact that the rural building lot must be larger than the lot on main street in order to provide the same degree of sanitary safety. The public can be protected only if it will incorporate into the subdivision regulations standards and principles for minimum lot sizes to meet all of the soil conditions prevailing in the community.

In order to facilitate the establishment of minimum lot areas for various soil conditions, the planning agency should provide a soil map classifying all areas of the community, and a public sewer and water map showing both the location of existing facilities and the areas which can feasibly be served.[26] These two maps should be made a part of the subdivision regulations. A range of residential lot sizes, could then be specified that vary according to the adsorption value of the land and the availability or lack of public sewerage and water facilities.

Land which is swampy or subject to flooding should be restricted to some use other than residential. In many cities, however, such land is frequently permitted to be developed for residential use. Residential development should be restricted to relatively low density in order to reduce public costs in time of flood. Residences should be prohibited in any such area where public water and sewage service is not available.[27] It has been recommended that "larger lots be required in flooded, swampy, or areas with a high water table."[28]

The APHA, Committee on Hygiene of Housing and Mr. Hoover, agree closely on recommendations of minimum lot areas for subdivisions where public water and sewerage facilities are not available. Mr. Hoover, however, has given a better suggested range of lot sizes. Table 4. which is adapted from both of the sources cited, sets forth suggested minimum lot sizes for subdivision where public water and sewerage facilities are not available. This table assumes that there will be around 50 gallons of sewage per person per day. This table is based on the sewage produced by a family of four,

Table 4. Suggested Range of Minimum Lot Sizes for Suburban Subdivisions

Soil Types	Required * Facilities Family of 4 (Li. Ft.)	Area of Sewerage Systems (Sq.Ft.) Grades 0-5%	Area of Sewerage Systems (Sq.Ft.) Grades 6% & Over	Minimum Lot Sizes (Sq. Ft.) Grade 0-5% Type of Water Service Public	Minimum Lot Sizes (Sq. Ft.) Grade 0-5% Type of Water Service Private	Minimum Lot Sizes (Sq. Ft.) Grade 6% & Over Type of Water Service Public	Minimum Lot Sizes (Sq. Ft.) Grade 6% & Over Type of Water Service Private
1. Clean Course Sand or Gravel	60' of Tile and 2' wide Trench	120	210	5,000	20,000	6,000	20,000
2. Find Sand or Light Sand	80' of Tile and 2' wide Trench	190	350	6,000	20,000	8,000	20,000
3. Fine Sand with Some Clay or Loam	120' of Tile and 2.5' Trench	780	1,200	8,000	20,000	12,000	20,000
4. Clay with Some Sand or Gravel	320' of Tile and 3' wide Trench	3,150	4,700	10,000	20,000	15,000	20,000
5. Heavy Clay, Shallow Bed-rock, or Impervious Layer	Subsurface Sand Filter with Discharge into Flowing stream, or Public Sewer	-	-	15,000	20,000	20,000	20,000
6. Flooded, Swampy, or with a High Water Table	Filling and Public Sewer	-	-	½ acre	½ acre	½ acre	½ acre

* Assumes that there will be around 50 gallons of sewerage produced for each person in the family per day, or 200 gallons per day for a family of 4.

but it could be easily adapted to the requirements of a family of any given size.

In order to establish lot area requirements for open-country areas, all the factors set forth in Table 4 must be taken into consideration. Mr. Hoover points out that subdivision control over suburban development is just as important as it has been found to be in the heavily built-up areas.[29] This fact is being recognized by many government agencies and minimum lot sizes are emerging in public regulations affecting suburban areas. This is particularly true in cases where a public water supply or sewerage system is not available.

Raw Land Cost

It is important to evaluate the effect of land cost on the size of residential lots principally because cost has been more often than not the only consideration used to establish lot sizes. Mr. Garrett Eckbo said: "The sacrifice of essential space to the twin bogymen of cost and mechanical gadetry--rather than basing optimum standards on biotechnic needs are too apt to produce the slums of tomorrow."[30]

The prevention of slum development is an important goal of good urban planning. The cost of slums is evident in all cities and such conditions may be traced in part to the past practice of establishing minimum lot areas based largely on costs of land and land improvements.[31]

The cost of habitable residential land may properly be classified into, first, raw land cost and, second, land preparation cost. The effect of land preparation cost will be evaluated later in this chapter.

Raw land may be classed, for the purpose of examining its value, into, first, an agent for the production of useful and enjoyable goods, and, second, an agent which affords sites for dwellings, industries, commercial, or social activities. The latter is in a very real sense a production use also. The value in both cases is the amount of money that people are willing to pay for the privilege of using the land.[32] In the case of land as an agent of production of useful and enjoyable goods, a limit is set on the value of the land by the amount of goods that the land will yield over and above the cost of production. Such land value is important in this thesis only in-so-far as it fixes a value per-acre of rural or raw land for agricultural or forestry purposes from which the increased value for other uses may be reckoned.

The value of land used for sites for dwellings and other urban purposes depends upon the intensity of the proposed use. The value of such land arises in large measure from the density of population and population growth, and the presence of activities dependent for financial profit on nearness to the center of population.

Human psychology also plays an important part in the value assigned to a parcel of land. Man is a gregarious animal and isolation is a dreaded punishment. A highly valued residential location is one which facilitates frequent contacts with one's fellow-man and full participation in the activities of the community. Certainly it is not difficult to find evidence that a location which restricts or prevents such social interaction is considered undesirable by many people.[33]

The cost of raw land that is to be used for residential development may range from a few dollars to many thousands of dollars per acre. The cost is a factor in establishing lot sizes since developers usually eroneously consider land as a marketable product that may be priced for sale on a per-unit-cost basis. If the unit-cost is based on a square foot of land, the developer will use the smallest area in square feet that he is permitted to sell for a residential lot. As will be shown later, however, the cost of raw land is only a small percentage of the total cost of an improved lot.

Since the cost of raw land varies so widely, no attempt will be made to evaluate any particular raw-land site. The cost of the raw land that is needed to develop residential lots of 13 different sizes will be determined. This is done by determining the area of land that is needed to develop and service each of the 13 lot sizes and calculating the cost for each lot-size at raw-land costs that vary from $100.00 to $5,000.00 per acre. The land area needed for the lot area, and that needed for each service to the lot, are shown in Table 5. Figure 1 is a graphic presentation of the findings from Table 5. In this figure raw land is plotted as the ordinate and land preparation cost is plotted as the abscissa for the 13 lot-area curves shown in Column 1 of Table 5.

Land Preparation Cost

The costs involved in changing raw land into residential lots include the cost of providing sanitary sewerage, public water mains, street grading and paving, curbs and gutters, sidewalks, storm-water drainage, and public recreation and school facilities to serve the new residences. A practical method of evaluating the effect of these service costs on recommended lot sizes is to compare the cost of developing a range of lot sizes. Thus it is possible to determine the added cost of larger lots.

The cost of each of the services listed above, except public recreation and school facilities, should normally vary exactly with the lot width since they are ordinarily installed across the short dimension of the lot.

The cost of services to a residential lot are not all included on or adjacent to the lot being considered. Connecting streets that do not immediately serve any lot are necessary. Likewise, sewer lines require connections and outfalls that do not immediately serve any lots. Water mains, storm drains, sidewalks, curbs and gutters, all require installations in a continuous pattern so that more lineal footage is required than there is lot frontage in any residential area. After examining plat plans and computing the connecting links required to serve residential areas, it is concluded that between 15 and 30 per cent more lineal footage is actually required than would be required to simply provide the service across the narrow dimension of all of the lots inside a representative residential area. In the following discussion of the cost of individual service to residential lots the cost is calculated on the assumption that all utilities, except curb and gutters, sidewalks, public school and recreation facilities, serve two lots, one on each side of the street, per unit of length. It is also assumed that the length of all services required includes an additional 20 per cent to cover connectors. That is, only half of the cost of streets and utilities is charageable to any one lot. Sidewalks may be provided on either one or both sides of a street. However, in this example they are assumed to be on both sides. In the tables that follow, facility specifications change at different densities of population because of the particular nature of the facility.

Sanitary sewerage lines are normally provided for by pipe sizes that are calculated on the basis of population density. The cost of providing this service varies with pipe size as follows:

Density per Gross Acre	Required Pipe Size (inches)	Cost per Lineal Foot
20 to 22	24	$10.00
10 to 19	20	9.00
8 and 9	18	8.00
7 and 8	16	7.50
5 and 6	14	7.00
3 and 4	10	6.50
1 and 2	8	5.00

Public water is assumed to be provided to the residential lots in pipe sizes and at costs that vary with the densities per gross residential acre as follows:

Density per Gross Acre	Required Pipe Size (inches)	Cost per Lineal Foot
10 to 22	8	$6.00
4 to 9	6	5.00
1 to 3	4	4.00

Streets are assumed to have paved surfaces 32 feet wide in public rights-of-way that are 50 feet wide. There is no attempt made here to establish paving specifications. However, the following per-foot paving costs reflect higher specifications for higher densities. In order to determine the per-lot cost of street paving, the following assumptions are made:

Population Density per Gross Acre	Cost per Lineal Foot of Paving and Grading
15 to 22	$25.00
10 to 15	20.00
5 to 10	15.00
3 to 5	10.00
1 to 3	8.00

It is necessary to add a cost for grading and for raw land to the paving cost before the whole cost of streets can be determined. Grading costs depend on the type of topography and soil conditions that exist in the area under consideration. The cost figures can be obtained in any community from competent contractors or street or highway departments. In the example used here a flat cost of $2.00 per lineal foot of street is assumed.

The cost of the street rights-of-way depends on the cost of raw land. Such costs vary widely. The method illustrated in this thesis involves comparing the total costs of developing various lot sizes on raw land at any per-acre cost. The method employs a system that arrives at a total per-lot cost for lot improvements in terms of a fixed amount of money, plus an area in acres of raw land, times a variable "a" which represents the cost per acre of raw land.

Curbs and gutters along streets are calculated at a cost per lineal foot across the lot width. The price used here is $2.00 per foot of the lot width for one side of the street.

Sidewalks are assumed to be paved six feet wide, and the cost is calculated at $1.50 per lineal foot along one side of the street.

Storm drainage costs do not necessarily vary with density of development. There is a density of development, however, below which engineers feel that such service in uneconomical and unnecessary. The city engineers of the city governments in the metropolitan area of Atlanta, agree that storm drainage is not required in residential developments under ordinary circumstances in those areas for developments in which lot sizes average 10,000 square feet and over. The point at which this service might be unnecessary must be determined for each section of each community depending on topography, soil conditions, and annual rainfall. It is therefore assumed in this thesis, that storm drainage is not required in areas where residential lots are 10,000 square feet or more in area. The cost of a storm drain is estimated to be $8.00 per lineal foot.

Public recreation facilities do not occur on the residential lot, but they are made necessary as a result of residential developments. It appears that their costs are a legitimate charge against residential lots. The cost of public recreation may be determined for any community by finding the total annual expenditure for such services and then establish a per-lot cost. Capital cost alone could not be obtained for the Atlanta area. The recreation cost figures are therefore not entirely consistant with the figures for other facilities. In the present study the annual park and recreation budgets for the year 1954 and 1955 were averaged for the City of Atlanta and the per-family cost found, based on the average Atlanta family of 3.43 persons. The cost, per-family, in Atlanta came to $9.00. However, to this annual cost of service must be added the cost of raw land required to serve each residential family. It is determined from recommendations of the writers on public recreation that 700 square feet or 0.016 acres of public park area is required per-family. It is assumed that park requirements do not vary with the density of population.

Public school costs involve both structure and land costs. The structure costs are relatively fixed, and may be readily found in any community. The land cost will vary. It is ascertained that a 500-pupil school requires 20 acres of land. At the rate of 0.75 school-age children per family, a school is required for every 625 families. That is, 0.03 acres of land is chargeable to each family for public-school sites. School-structure costs used in this study are based on an example of a new school building erected in the Atlanta area. The structure was built to accommodate 500 pupils and cost $225,000.00. At the rate of 0.75 school-age children per family, the cost of the building amounts to $330.00 per family. The total per-family or per-lot cost, assuming one-family lots, is $330.00 plus 0.03a. The variable "a" is the per-acre raw-land cost.

Table 5 is a compilation of the data described in this section. The first column gives the gross areas in square feet for 13 of the most common residential lot sizes. Also, the net residential lot area is shown in acres. The net figure equals gross lot area less the area of street right-of-way charged to that lot. The second column gives the width in feet of the lot area shown in Column 1. The third column gives the number of lots per-gross-acre for residential developments laid out in the lot areas shown in Column 1. Columns 4 through 11 present facility-costs developed as presented above. The whole numbers in the last column are the total in dollars of Columns 4 through 11, and the decimal fraction is a total of the fractions in Columns 1, 6, 10, and 11. The last column shows the total cost for developing a lot with the area shown in Column 1, in terms of the fixed cost plus a variable raw-land area and cost.

In Figure 1 the compilation of the land preparation costs is plotted as the abscissa for the 13 most common lot-areas found to exist. The lot-area curves were located by substituting various raw land costs in hundreds of dollars per acre in the equations in Column 12 of Table 5. Figure 1 may be used to determine the developed per-lot cost on raw land of varying costs.

The importance of Figure 1 is, however, to point out that there is not the difference in developed-lot costs that

TABLE 5. LAND AND SERVICE COST OF RESIDENTIAL LOTS

LOT SIZE			NO. LOTS PER GROSS ACRE	COST PER LOT FOR LAND AND SERVICE (DOLLARS)								
GROSS SQ. FT.	NET ACRES	WIDTH FT.		WATER	SEWER	STREETS-PAVING & GRADING	CURB & GUTTER	SIDE WALKS	STORM DRAIN	RECREATION	SCHOOL	TOTAL PER LOT
1		2	3	4	5	6	7	8	9	10	11	12
2000	.032	25	21.7	90	150	406 +.014a	50	37	120	9 +.016a	330+.030a	1192+.092a
3000	.052	30	14.5	108	162	396+.017a	60	45	144	9 +.016a	330 +.030a	1254+.115 a
4000	.069	40	10.8	144	216	528+.023a	80	60	192	9 +.016a	330 +.030a	1559+.038a
5000	.089	45	8.7	136	216	460+.026a	90	68	216	9 +.016a	330+.030a	1525+.161 a
6000	.112	55	7.3	166	232	562+.032a	110	82	264	9 +.016a	330+.030a	1755+.170 a
7000	.127	60	6.2	180	270	612 +.034a	120	90	288	9 +.016a	330+.030a	1899+.207 a
8000	.147	65	5.4	196	234	663+.037a	130	98	312	9 +.016a	330+.030a	1972+.230a
9000	.163	75	4.8	216	288	540 +.043a	150	112	360	9 +.016a	330+.030a	2005+.252a
10,000	.184	80	4.4	240	240	576+.046a	-	-	-	9 +.016a	330+.030a	1375+.276a
12,000	.224	90	3.6	216	270	648+.052a	-	-	-	9 +.016a	330+.030a	1473+.322a
15,000	.286	100	2.9	240	300	600+.057a	-	-	-	9 +.016a	330+.030a	1479+.389a
20,000	.396	110	2.2	264	330	660+.063a	-	-	-	9 +.016a	330+.030a	1593+.505a
1ACRE	.914	150	1.0	360	450	900+.086a	-	-	-	9 +.016a	330+.030a	2049+1.046a

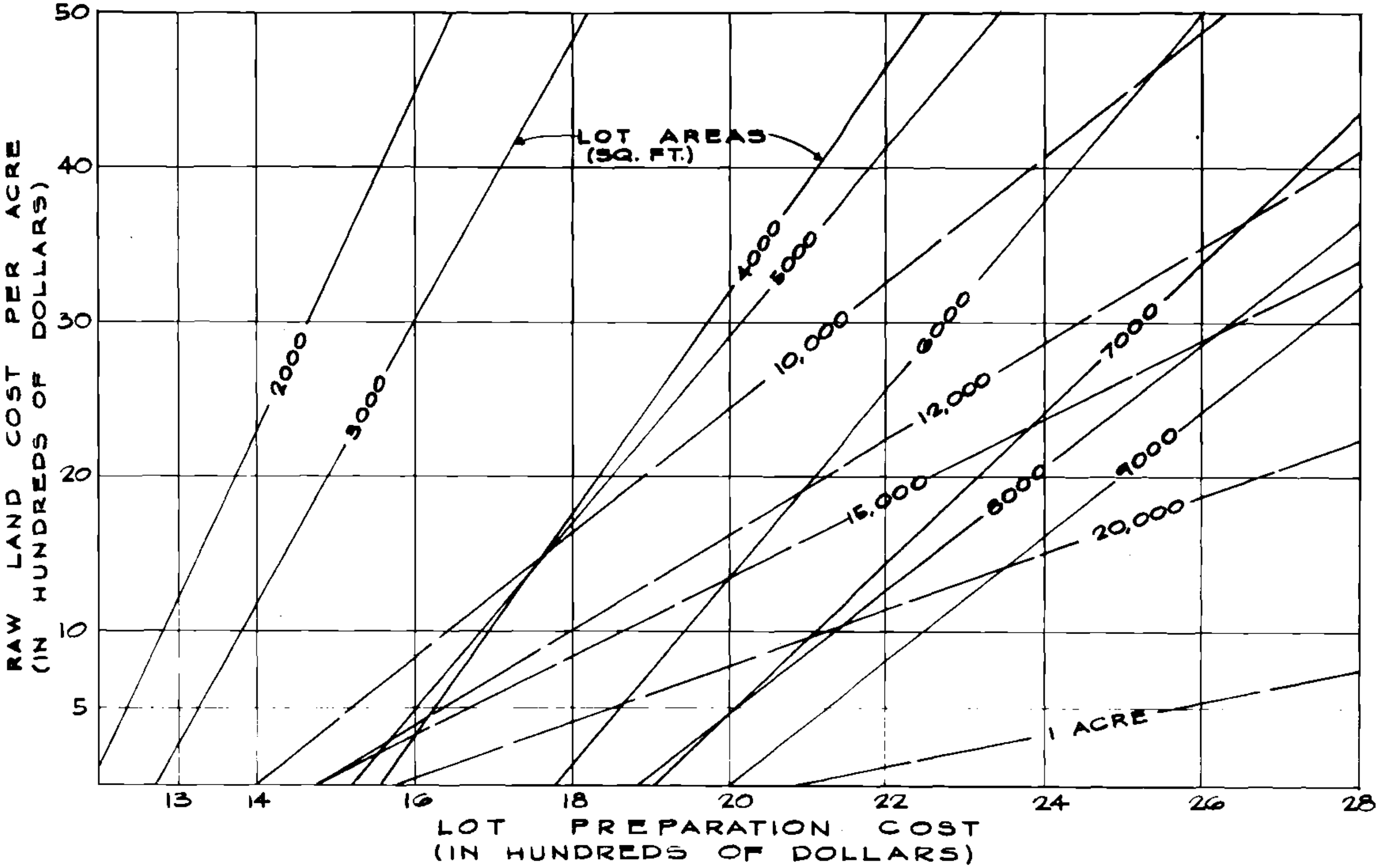

FIG. 1. LOT PREPARATION COST ON RAW LAND AT VARYING COST

developers usually decry between small and larger lot areas. It may be noted, for instance, that a cluster of curves fall between $1,600 and $2,200 per-lot on raw land at $1,000 per-acre. Included in this cluster are lot areas of 4,000, 5,000, 6,000, 10,000, 12,000 and 15,000 square feet. On raw land at $1,000 per acre, lots of 4,000 and 5,000 square feet may be developed at almost identical costs.

The range of developed-lot costs on raw land at $1,000 per acre is from $1,280 to $3,090 each, with lots ranging from 2,000 square feet to one acre. Twenty-thousand square-foot-lots may be developed on $600 per acre raw land at the same total cost as the six-thousand-square-foot lot; on $900 per acre land, at the same cost as the seven-thousand-square-foot lot; and $1,200 on acre land, at the same as the 8,000 square foot lot. There is a difference of $560 between the cost of 5,000 and 9,000 square-foot lots on raw land at $1,000 an acre. On land which costs up to $1,200 per acre, 5,000 square foot lots are less costly to develop than those of 4,000 square feet. This occurs because of the requirements for more costly services for developments at densities of ten families or more per acre than are needed for lower densities.

Municipal services not reflected in these calculations include fire and police protection and site grading. The first two are costs normally paid out of real estate tax levies. It was found by Wheaton and Shussheim[34] that the typical urban house and lot assessed for taxes in the Boston area at $5,000 yielded around $200 annually. It is assumed that tax levies cover the cost of police and fire protection.

There is such a wide variety of sizes and shapes of structures and types of topography that any figure used for site grading would be generally inapplicable. The type of terrain and the type of structure, however, will effect the cost of preparing the lot for habitation. A single-family house may be placed on very hilly or rough land at a very much lower site grading cost than a large multi-storied structure. This fact must be considered for each area of a community, and lot areas conditioned and uses controlled so that prohibitive costs for site preparation do not occur.

Wheaton and Sussheim[35] found that, in three residential suburban areas around Boston, the full value of capital facilities required by residential development ran from $1,900 to $2,800 per house. These writers concluded that such costs vary widely according to location and density of development.[36] From low to high densities the cost increased as much as 50 per cent. In individual communities, the cost of these services ranged from three thousand to thirty-seven hundred dollars per house.[37] The findings of these writers approximate the total costs found in Table 5.

It appears that planners and public officials may require larger lot areas without unduly penalizing land owners and developers. The cost of lot development does not rise in proportion to the increase in lot area. An increase in the minimum lot area requirement from 4,000 square feet to 10,000 square feet, an area increase of 40 per cent, decreases the per-lot cost on raw land at $1,000 an acre, by 3.7 per cent. An increase in area requirements from 3,000 to 5,000 square feet increases area by 60 per cent, but increases costs only 24 per cent. The cost of raw land and lot improvements do not increase proportionately to the increase in lot areas. This is an important fact not generally recognized.

Dwelling Structure Foundation Area Requirements

The foundation area requirements of dwelling units vary widely with design and type of residential accommodation. In this section of the thesis only the actual area covered by the structure is considered. No consideration is given to the outdoor areas either for living or for service. It is not proposed to enter the controversy as to the desirability of any one type of dwelling unit over another. It is assumed that there is a need and a popular desire for all of the types of residential accommodations. On this point Fredrick J. Adams says:

> People do not live in crowded neighborhoods because of congestion, but because of the convenience of location. It is not even reasonable to assume that the prevalence of apartment houses in our large cities is because most urban families prefer that manner of living . . . but this form of structure was erected by the developer as the most profitable type of residential building which can carry the highest amount of land cost.[60]

Single-Family Houses.--The recommended per-family floor areas vary widely, as do the methods of determining and establishing these requirements. Some writers suggest that a more accurate index of congestion is reflected by the gross floor area per room and the occupancy rate per room than is indicated by the total floor area per family.

The per-family gross floor area recommended by American and English authorities differ considerably. One writer says that the reason for this difference is that: "The element of importance of apartments in Europe and single-family houses in America is that in Europe, housing is related directly to the availability of land; in America to the cost of land."[38] In England, the average three-bedroom home built between World War I and World War II contained from 750 to 850 square feet of floor space and was two stories high. This gave an average foundation area of from 375 to 425 square feet.[39] In 1946, an English Association for Planning and Regional Reconstruction made an official recommendation that the three-bedroom house should have a total floor area of not less than 900 square feet. This recommendation was made after a study of people's wants and desires in relation to housing accommodations.[40] The Association suggested that 1000 square feet of floor area is a desirable minimum, but that such a requirement would eliminate a great number of potential home owners. The recommended standard of 900 square feet for two-story dwellings would require a foundation area of 450 square feet. Single-family one-story houses are relatively rare in England, whereas they are common in America.

It is assumed, for the present inquiry, that all single-family two-bedroom houses in America are one story. According to the findings earlier in this chapter, the foundation for this type of accommodation will require a minimum of 1,260 square feet. Thomas Adams refers to the single-family house as one having a: " . . . 600 square foot floor plan."[41] The question, how much area should the structure cover, resolves itself into, what per cent of the lot should the structure cover? This however, is more applicable to types of accommodation other than the single-family house. In view of the wide range of suggested areas, it may prove of greater value in preventing congestion to establish a maximum coverage of lots in terms of a percentage rather than an actual area. In single-family estate areas, pure economics will prevent overcrowding. However, the purpose of this study is to establish the actual area that may be covered by the structure regardless of lot size. This study is directed toward recommended lot sizes rather than minimum lot sizes, it appears desirable to follow more closely the floor areas given in Table 2.(as determined from gross floor area per room and the occupancy rate) than those of others which suggest greater areas.

In conclusion, therefore, it is assumed that the average single-family three-bedroom house will occupy 1,575 square feet of land area. For two bedroom structures, 1260 square feet appears appropriate in view of the recommendations for gross-floor-area-per-room given earlier in this chapter. These are the two most common types of single-family houses built in America.

Two-family houses.--The two-family house is defined as a structure designed for two dwelling units, either attached side-by-side or one above the other. The foundation area requirements for a two-family house, containing two bedrooms per dwelling unit attached side-by-side, would be approximately twice the area required for a two-bedroom single-family house or approximately 2520 square feet. However, the foundation area requirement for a similar two-family house with the units placed one above the other would appear to be about the same or slightly above that of the two-bedroom single-family house. The single-family house would not need to include area for access to the upper floor, as would the two-family house. Due to the fact that two-family houses usually have smaller rooms than the single-family structure, it is assumed that the two-family, two-story structure will require the same foundation area as the two-bedroom single-family house, namely, 1260 square feet.

Multi-family structures.--A multi-family structure is one that contains three or more dwelling units. This classification includes, row houses, garden apartments, walk-up, and elevator apartments. In view of the great variety of designs, sizes, shapes, and bulks of such structures, it is impossible to determine a foundation area requirement for any classification that would be generally applicable. It is, however, possible to do so in terms of a combination of numbers of stories and numbers of dwelling units of a given area located in a particular structure. The difficulty involved in such computations were recognized by Thomas Adams when he stated: " . . . no basis can be suggested for determining sizes of apartment buildings for the purpose of indicating the exact size of lots they should occupy."[42] Few, if any, sites are planned from the beginning for multi-family structures.

By adopting the optimum per-family gross floor areas found to be required for the range of family sizes included in Table 3, it is feasible to determine foundation area requirements for selected multi-family structures. For example, a structure that contains four two-bedroom dwelling units and is two stories high would require a foundation area of 2520 square feet, assuming 1260 square feet of floor area per family. This amounts to 630 square feet of foundation area per family for such a structure. Foundation area requirements for structures with selected combinations of stories and numbers of dwelling units of specific sizes are set forth in Table 6.

<u>Group housing projects</u>.--Group housing projects are considered to be any combination of one-, two-, and multi-family structures

Table 6. Foundation Area Requirements for Selected Multi-Family Structures

Number of Stories	Number of Dwelling Units	Foundation Area Requirements (sq. ft.)*	Area Per Family (sq. ft.)
2	5	3,280	655
2	6	3,990	655
2	7	4,600	655
2	10	6,560	655
3	6	2,630	430
3	7	3,080	430
3	8	3,500	430
3	10	4,380	430
4	8	2,630	328
4	10	3,280	328
5	10	2,630	263
5	12	3,150	263
6	10	2,190	219
6	12	2,630	219
6	16	3,500	219
8	16	2,630	164
8	18	2,950	164

* Based on 1,260 square feet, gross floor area, per two-bedroom dwelling unit.

occupying a parcel of land and comprising a single development. The great possibility of combinations of dwelling types in group housing projects defy any precise determination of foundation area requirements. D. A. Grossman has prepared what he calls a "nomograph" with which to determine the density standard for developments containing a mixture of housing types. He suggests that it may be used to balance the densities in such mixed developments. The "nomograph" is a graph which, when worked out, will indicate the particular density to be achieved from the mixing of specified residential types. In order to prepare the graph, three principal kinds of data are necessary. These are the desired average net density, the desired ratio of building area to land area, and the allowable types of structures for the proposed area. One other figure, the average dwelling unit area, is required. The desired nomograph is the graph of the solutions to two lineal equations containing three or more variables.[43]

It is reasonable to conclude that the only solution to the problem of determining building coverage, or foundation area, in such mixed developments is to establish a percentage of the land that may be covered by the structures. Recommendations of this percentage have been made by many writers for practically every conceivable type, or combination of types of structures and densities. The complexity of the many solutions offered appears to boil down to simply determining how much open space is absolutely required about dwelling structures, and how much is desirable. Frederick J. Adams suggests that, in high-density residential areas, lot coverage be limited to 30 per cent of the net residential area.[44] Thomas Adams, however, says that: " . . . not more than 40 to 50 per cent of any residential lot should be built upon."[45] Emanuel states that building coverage must be related to building height before it has any significance; that 20 to 30 per cent net coverage appears to be practical; and that structures thirteen or more stories high should be planned with net lot coverage of less than 20 per cent, but more nearly approaching 15 per cent.[46] Ford states that: " . . . a number of the most successful recent apartment developments cover 30, 25, and even 20 per cent of the (net) lot areas."[47] The recommendations of the American Public Health Association Committee on the Hygiene of Housing, for lot coverage by dwelling types, are presented in Table 7.

Table 7. Recommended Lot Coverage by Dwelling Types[48]

Structure Type	Percentage of Lot Covered by Structure
Single-family	30
Two-family	30
Multi-family	
2-story	30
6-story	25
9-story	20
13-story	17

A majority of urban zoning ordinances establish some limitation on lot coverage. The Federal Housing Administration limits coverage to 30 per cent. The Federal Works Agency established a maximum of 25 per cent for wartime housing. These percentages apply primarily to single-family houses. The United States Public Housing Authority recommended that, when minimum spaces are adhered to, a coverage of 30 per cent is about the top limit, though this may sometimes be exceeded.[49]

The consensus is that the maximum lot coverage of most residential structures should be limited to 30 per cent. In the case of group-housing projects, it would appear reasonable to say that, regardless of the types of structures, they should not cover more than 30 per cent of the net residential lot area.

Dwelling foundation area requirements vary with the type of structure. Recommended foundation area allotments for the dwelling types in group housing projects are the same as those set forth for individual one-, two-, and multi-family structures.

Light, Air, Amenities, and Sound Insulation Requirements

Light, air, amenity, and sound insulation area requirements are related to residential density and to net and gross residential lot areas. Historically, the necessity of sunlight and air for buildings has been recognized since the reign of Richard Coeur De Lion in 1189. In 1832 his principles were embodied in a British statue law which provided: " . . . if a window in a building has uninterruptedly enjoyed the access of light for a period of 20 years, that right becomes permanent."[50] In the studies made by the <u>Regional Survey of New York and Its Environs</u>, it is stated that:

> . . . it is where people live that the need of open space about buildings for light and ventilation is greatest. Dwelling places are more fully used for longer periods of each day by all members of families than is true for other areas of a city.[51]

Their studies also point out that the difficulty of providing space about buildings is due, in general, to a lack of sufficient control over their distribution and not to a lack of space.[52] The most important consideration in all housing development is the right quality of spaciousness and agreeable surroundings to meet social needs, rather than any particular type or class of structures. No amount of public park area can take the place of the necessary private space that should be made available about residential buildings.

Space requirements about buildings are a direct result of bio-technic needs for human health. Sunlight and sound insulation distance are necessary for physical health, while amenities appear to be a prerequisite to psychological well being. As a practical minimum, sufficient light can be obtained through restrictions requiring first, that all rooms used for habitation have direct access to the open air (that is, that buildings should not be more than two rooms deep) and, second, that sufficient space be provided at right angles to all front and rear walls of buildings, so that every window receives an angle of light of not less than 45 degrees.[53] This would have the effect of limiting the height of structures to one times the distance between them. Zisman says that:

> In its simplest terms, housing provides shelter . . . a shed from rain, a shield against wind, a sun shade. To these primitive notions of what constitutes adequate housing, concepts of standards have been added . . . sufficient space for persons and furnishings; division of space for privacy and living; for sanitation. Still more standards for light, air, and amenities of health and recreation.[54]

In the City of Manchester Plan, standards for open space about buildings have been established on the basis of rooms per gross acre and gross space per habitable room as shown in Table 8.

Table 8. Space About Buildings Per Habitable Room for Various Densities

No. of Stories I	Rooms Per Gross Acre* II	Gross Space About Buildings Per Habitable Room III (Square Feet)
3	139	230
4	151	227
5	158	225
6	164	224
7	168	224
8	171	223
9	174	222
10	177	222

*Based on spacing of parallel blocks, (300 feet long, 25 feet deep, 40 feet end to end), with 25 degrees daylight angle, and on the assumption of 250 square feet total floor area per habitable room.

Table 8. has established no distance requirement other than that resulting from a 25-degree light angle requirement. This is in general agreement with the opinion of other British writers who hold that a 25-degree light angle is sufficient, in view of the acceptance of the findings that daylight has a useful effect equal to from one-fourth to one-third of that of sunlight. Heydecker and Goodrich reason that an acceptable standard for sunlight is one-half hour of direct sunlight (at noon-time intensity) for every living and sleeping room on

December 21st. This can be achieved if buildings are so spaced that there is an unobstructed angle of light of approximately 20 degrees from the center of the floor in the dwelling rooms to the top of the building opposite. This means that the distance between buildings should be 2.4 times their height above the first habitable floor windowsill.[55] George Ford says of this recommendation that:

> In view of the impossibility of realizing these ideal standards on higher priced land, it is proceeded to show how far it is practical to bring sunlight into every window, and to indicate that in its health-giving effect, light from the sky or 'skyshine' is equal to approximately one-third to one-fourth of the value of direct sunlight.[56]

Buildings would have to be about twice as far apart as they are high to assure one-half hour of direct sunlight to every window. However, a well-recognized practice is to place buildings only as far apart as they are high. This is a conditioning of the scientific findings in deference to land cost, plus the desire to make building arrangements such that a degree of compactness is felt in order to achieve an urban feeling. Gibberd indicates that in order to achieve an urban character of compactness, relatively high densities of not less than 30 persons per acre must be achieved in residential areas.[57] The recognized practice is to require a one-to-one ratio of structure height to horizontal distance between them, in order to achieve the desired light, air, and open space.

Much has been written about the desirability of street setback requirements for sound insulation. The primary purpose of setbacks is to provide areas for insulation of the noise of one structure from another, or the noise of streets from structures. Mr. Koska says that their purpose is twofold: first, to provide a barrier between the noise, dust and fumes of the street and the house; second, to create a neighborhood atmosphere of "living" space. The front yard should not be sacrificed for the purpose of widening the street, since it would defeat the purpose for which it was reserved.[58] He suggests also that single-family houses should not be closer together than 20 feet.[59] Opinions differ between English thinking on the subject and that of the United States. The English writer, Edwards, says of a British regulation which requires a 15-foot setback from street rights-of-way for low-cost row houses: "It is a waste of good agricultural land and an expression of unsociability. Such developments are described as 'hygienic deserts'."[60] He says that there is no hygienic reason that houses should be set back 15 feet, nor any other distance, but with respect to "amenities of living" there is some logic in such requirements.[61]

Yard requirements vary widely. Ford recommends that rear yards should be one-third as deep from front to rear, as the structure is high; that side yards should be one-sixth the structure height; and that front yards be calculated at the rate of one foot of horizontal distance for each two feet of structure height. In this discussion Ford is analyzing the multi-family house.[62]

Thomas Adams says: "Detached houses should have a minimum of 10 feet between them, i.e., the width of a house on a 30-foot lot should be limited to 20 feet."[63] Koska suggests that side yards should be such that eight feet remains between the structure and a side lot line, and that there should be not less than 20 feet between structures.[64] For one-story structures he suggested that 25 per cent of lot depth and a minimum of 25 feet separate the structure from the rear lot line. This same requirement is suggested for setbacks from the street right-of-way.

Thomas Adams summarized the consensus on amenities as follows:

> Consciously or unconsciously most of us like the city and the country for what is best in both. The one because it meets our social demands and claims all our philosophy and the other because it gives us so much and demands so little. But a well balanced city with somewhat the flavor of the country is the ideal to most men. When we can enjoy its excitements and social values, and at the same time throw open the gate of the garden where God walks from morning to morning; we have greater satisfaction than when we have to live in a crowded city or the isolated country district.[65]

Running through all planning literature is a constant search for the "right" combination of town and country. Emanuel quoted Thomas Sharp as saying: "There seems to have gotten about an idea that there is virtue in mere space as such, but there is a great deal to be said for maintaining a sense of enclosure in a town, and a sense of compactness and intimacy."[66] This element of urban compactness is stressed quite strongly by J. M. Richards. He says that the new towns are:

> . . . composed, for the most part, of scattered two-story dwellings, separated by great spaces; their inhabitants, instead of feeling themselves secure within an environment devoted to their convenience and pleasure, find themselves marooned in a desert of grass verges and concrete road-ways.[67]

The City of Manchester Plan describes amenity in quantitative terms, yet the author concludes that any reduction in the space between buildings, below the minimum required to enable their grounds to be well kept, would also result in a growing sense of oppressiveness and closeness. The point at which loss of external amenity becomes apparent is only approximately the point at which marked deterioration in standards of internal lighting and sunshine penetration begins.[68] Churchill and Ludlow observe what appears to substantiate the feelings of other writers. They conclude that:

> Even with sufficient space between them, however, tall buildings do not give the same feeling of openness as low buildings. As a person stands in the court between 12 or 16 story buildings, or looks out of their windows, there is a very great difference between the scale of the building and the scale of a man. Many persons feel dwarfed and oppressed when a 12 or 16 story building towers above them. Whereas even with the same angles to the sky, three or four story buildings would give a greater feeling of openness and make the individual seem more significant and more able to cope with his surroundings.[69]

Emanuel quotes Mumford as reasoning, after a study of new towns in England, that the strong tendencies toward increasing openness in towns is a revolt against congestion and disorder; that a space hungry generation has developed eyes that are bigger than its stomach.[70]

Conclusions.--Now that the consensus has been expressed, it is possible to establish general specifications as to area requirements for light, air, and sound insulation, and for amenities.

For light and air, there appears to be general agreement that the most practical requirement is a one-to-one ratio of structure height to distance between structures. This requires that varying standards be recognized for the dwelling types.

Single-family dwellings should be no closer together than 20 feet. Rear yards should be not less than one-fourth of lot depth and in no case less than 25 feet. Front-yard requirements depend to a large degree on the type of development desired; but for average conditions, it is recommended that a minimum of 25 to 30 feet from the street right-of-way be observed.

When light, air, and amenities are provided for, the areas shown in Table 9 are required.

Table 9. Lot Areas Required to Meet Light, Air, Amenities, and Sound Insulation Distances for a Single-family Structure

Area Required for:	Area(Square Feet).
Dwelling structure	1575
Side Yards (2)	1080
Front Yard (25 feet setback)	1725
Rear Yard	1725
Total Lot Area	6105

Two-family structures present basically the same problems as those of single-family dwellings. However, the two-family structure with the dwelling units placed one above the other will require a minimum distance, equal to its height, from any other structure. A two-story structure with a pitched roof is normally 23 to 30 feet high. Therefore, it is necessary that these distances separate such structures, in order to meet the one-to-one ratio.

Multi-family accommodations, because of the great diversity of sizes, shapes, and heights, defy any general rule for establishing a required distance between them. It would appear, however, that such structures should be set back a distance equal to their height from the street onto which they front, and that a distance equal to twice the height should be required between the structure's rear wall and the rear wall of the structure opposite and across the rear yard. The rear yard should be as deep as the structure is high.

Side yard limits are more difficult to ascertain. In order to be consistent, these requirements should be met. In deference to land costs, to the fact that land is seldom subdivided for multi-family houses, and to the need to maintain a compactness of urbanity, these requirements are normally lessened. However, for the purposes of light, air, amenity, and sound insulation, there seems to be no justification for lessening them. If a structure ten stories high requires 100 feet at its front for these needs, that same 100 feet is needed at the sides either facing a side street or facing an adjoining lot. In most residential areas of a city these would be standards that should be required. In heavily built-up areas, however, such as those near the business districts of most large cities, this requirement would be tempered by land cost, and by the willingness of tenants to forego the needs of amenity of space and outlook for convenience of location. Even in such areas, there must be limits that the nearness of one structure may be to another for reasons of health and safety. It is recommended that there be a minimum of 40 feet between any window in such structure and any vertical structure on its level. That is, there should be a yard requirement of 20 feet on any lot containing such a structure.

Outdoor Activity Area Requirements on the Lot

Outdoor activities connected with a residential structure include recreation, service and gardening. It is pointed out by a majority of writers that no amount of public open space in residential areas can substitute for the recreational areas needed on the lot. It is the only area in which children may play under the homemaker's supervision while she is doing her housework. The playtime needs of children come during the same time that the mother is busy with her housework. The APHA Committee on the Hygiene of Housing, points out that, on the average, it requires 60 hours of housework per week to maintain the average household.[71] In view of the time required for housework, it is important that the children's play area be so located that the mother can observe the children while she works.

Recreational areas.--To determine the amount of play space required on individual lots, we shall examine play space requirements per-child on public playgrounds. The Regional Survey of New York and Its Environs makes a thorough study of the needs of space for children's play. Children were studied at play on various sizes of play lots in New York City, and calculations were made as to their play-space requirements. These studies show that such space requirements have in the past been allotted largely on the basis of guess work, and that careful study is necessary in order to determine the area required. By counting the children at play in public areas and measuring the space, the investigators were able to evaluate those areas as to their adequacy on the basis of the amount of "elbow room" observed. In play areas with adequate equipment and supervision, it was found that 93 square feet were needed per child at play. This does not include athletic field requirements. It includes play space for children from five to 15 years of age. Smaller children required less space for sandbox play; larger children required more for games. The study concludes that a fair standard, and one easily remembered, is 100 square feet for each child using the playground at any given time. The question is then raised as to what is the maximum percentage of the child-population expected to use the play space at any one time? After carefully checking within a radius of one-fourth mile of the facility, under a wide range of conditions in many cities, it was found that about one-seventh of the child population from five to fifteen years of age could be found on the playground at any one time. However, children were also using the school grounds for play space, and the findings of the study were adjusted to show that 25 per cent of the eligible child-population were assumed to use the playground at any one time. Since the child on the field requires 100 square feet, there should be 25 square feet of area per capita for the child population from five to fifteen years of age, or one acre for every 1,742 children of this age assumed to be using the facility.[72] This standard agrees with that suggested by Elizabeth Coit, who says that such lots should not be smaller than from 1,500 to 2,500 square feet in area.[73]

For children's play space on single-family lots, it is evident that the 100 square feet per child is not sufficient if the lot is assumed to accommodate one or two children. A space of 100 or 200 square feet would be only 10 by 10, or 10 by 20 feet in sizes, which would not be adequate. A play-space of 25 by 30 feet, or 750 square feet, is suggested by the Regional Survey of New York and Its Environs as a useful space for the two-or three-child family.[74] F. W. Dodge Corporation indicates that an area of 40 to 50 square feet per child is required for recreation space immediately related to the dwelling, and that a minimum area of 75 by 150 feet should be required for group housing units, public housing projects, or garden apartments.[75] This space must be so arranged that it is not crossed by walks, driveways, or cut up by flower or vegetable beds, if it is to be adequate for its proposed purpose.

An adult recreation area on a residential lot is as necessary as one for children. There is a need for a place of quiet relaxation, or even for lawn sports such as croquet. Demand for outdoor entertainment areas is also increasing. There is evidence of increasing demands for such space, possibly brought on by the high cost of construction which has caused increasingly smaller indoor living areas. A majority of prospective home builders voice preference for outdoor dining facilities over elaborate or separate dining rooms. The emphasis on informal living in America has built a booming industry in outdoor entertainment facilities. The space requirements for such use varies with the climate, the regional custom, and the dwelling type.

Generally, the single-family house-dweller expresses the strongest demand for outdoor living areas. His area requirements are also larger than like demands of the other dwelling-type occupants. The requirement for space depends on the type of activity, which may range from a simple space for a table to outdoor dancing, pavilions, swimming pools, bars, etc. Open space should be an integral part of the ground floor plan of the house. The size probably should be not less than one-half the total floor space of the house. A second way to evaluate this "outdoor room" area requirement is at the rate of 108 square feet per person, with a minimum of 216 square feet for any one-or two-person family. Sir Raymond Unwin recommends that recreation space on the lot be provided at the same rate that public recreation is required. This would be at the rate of seven acres per 1,000 persons; or, for his average family of 3.74 persons, home site recreation space would be 127 square yards (1143 square feet) per family. This would accommodate all of the family recreational needs.[76]

In summary, family on-lot recreational needs may be considered in the form of requirements for children and adults or on a per-family basis. The standard requirement for children appears to be 100 square feet for each child using the facility at any given time, with a minimum area of 750 square feet per dwelling unit.

Recommendations for adult recreation range from 750 square feet per dwelling, to Unwin's recommendation of 571 square feet. (Unwin's figure of 127 square yard included both children and adults, and it is assumed that he intended that half of this area be used for each class of participant). One hundred and eight square feet per person would give an area requirement for adults of 216 square feet, assuming that an average family of 3.1 includes two parents and 1.1 children. An average of these three different standards would be 512 square feet per dwelling unit for adult recreation needs.

Recreational needs for the whole family would appear to be approximately 1500 square feet per household; that is, an area of 750 square feet for the needs of children and the same area for the needs of adults. It is concluded that such area should be not less than 40 feet wide by 38 to 40 feet deep in order to be entirely usable for recreational purposes. It is advisable, however, to separate children's areas from those normally used by adults, since their activities are not always compatible. Recreation areas are often used by adults as mere sitting space or as entertainment areas, while children are accustomed to using their space for active play.

<u>Service area</u>.--Service areas are the next type of outdoor activity area to be considered on the residential lot. These include areas for vehicular and pedestrian access; automobile parking; and tool, fuel, and waste storage. These areas also vary according to the dwelling types. The service-area needs of single-family dwelling units will not necessarily be the same as those for multi-family units. Most recent zoning ordinances require off-street parking space for all land uses. The area required to park an automobile is 192 square feet, but if provision for two or more vehicles is made on the lot, a multiple of that figure does not suffice. Area is required for access to and from the parking area. The figure generally used is 216 to 220 square feet per parking space. Access for vehicular traffic onto the lot is ordinarily a single lane

driveway. This again must be enlarged to two lanes when the structures contains several dwelling units. For single-family lots, an area eight feet wide and the length of the front yard setback is suggested for vehicular access, that is, 8 by 30, or 240 square feet. The parking area for such a structure is generally the garage or carport. Such a structure should be not less than 12 feet wide by 26 feet long (or 312 square feet) to accommodate the larger model automobile. Unwin recommends that vehicular access and pedestrian paths, including parking space, should be reserved in single-story developments at the rate of 54 square yards (486 square feet) per dwelling unit, and 66 square yards (594 square feet) for each ground-floor dwelling unit, regardless of the number of stories in multi-story developments.[77]

Space for storage varies with the density of development. The single-family house with carport or garage attached, or with a basement normally would not require additional area for storage. However, multi-family structures, in which families live above ground level, require space for storage of tools, garbage, and discarded appliances of furniture. The Association for Planning and Regional Reconstruction states that: " . . . a garden shed should be provided for the storage of implements, fuel, vegetables, fruit, and bicycles, a minimum of 100 to 120 square feet is suggested."[78] Another British source suggests that outside storage area should be not less than 70 square feet.[79] The Chicago Planning Commission recommends 15 square feet per family for garbage storage and 180 square feet per family for equipment storage.[80] This totals 195 square feet per dwelling unit, which is larger than the English recommendations.

The area requirements necessary to satisfy the recommendations for storage and parking are shown in Table 10.

Table 10. Outdoor Storage and Parking Requirements

Type of Dwelling Unit	Area (Sq. Ft.)
Single-family house	500
Two-family house	1,000
Multi-family structures	490 per dwelling unit

Gardens.--Area for gardens is more appropriately considered for one-and two-family structures than for multi-family structures. The need in garden apartment type accommodations, however, would be similar to that of one-and two-family structures. Under the English social system, as opposed to that of America, the need is greater, since densities are higher and there is apparently a stronger motive for individual vegetable cultivation. This is caused by the pressure for preserving agricultural land in England due to a shortage that does not exist in this country. It is customary in England for each family in both public housing projects and private group housing developments to have what they designate as an "allotment", which is a specific plot of land assigned to each dwelling unit for vegetable culture. The "allotment" may be either on the lot occupied by the dwelling unit, or at some distance from it.

These areas vary in size, depending on the type of residential structure to which it belongs. They range in size from 1/70 to 1/16 of an acre. The only use of such allotments in the United States appears to have been in Radburn, New Jersey, where garden spaces were assigned for many of the dwellings. Gardens should be no greater in area than can be adequately cultivated by one person. This limitation appears to make an area of 2,000 square feet about the maximum space. The English area of 1/16 acre is about 2,700 square feet.

Landscape or flower gardens are so individual in nature that an average space requirement would be meaningless. The space required would depend on the economic level of the tenant. If a yardman were employed, a fairly large area might be maintained. A reasonable area for the householder, alone, to tend and maintain would be, perhaps, not more than 500 to 800 square feet.

Outdoor activity area requirements depend upon dwelling types and, to some extent, upon the customs and habits of people as they relate to outdoor living.

The primary outdoor area requirement is for light, air, amenities, and sound insulation. When this requirement is met, all other requirements for outdoor use on the lot are also met, as is made evident by a comparison of Table 9 and Table 12. Areas needed for recreation amount to approximately 1200 or 1400 square feet per family for single-family houses, and that area can be located within the rear yard of a lot that is 60 feet wide with a rear yard 20 to 24 feet deep. Since this is the largest area requirement for outdoor activities, it appears that it covers the requirements for the others. The light, air, and amenities requirement of a one-to-one ratio of structure height to distance between them, with a minimum of 25 feet between rear of structure and rear lot line, allows sufficient area for recreation. The side yards would contain an area of at least 12 feet by 20 feet if the structures were 24 feet high, or 240 square feet on each side for landscaping, outdoor dining facilities, parking, and vegetable gardens if desired. The front yard would be 25 feet deep, providing a space 25 by 60 on a 60-foot-wide lot for landscaping and access; i. e. an area of 1500 square feet.

The outdoor activity area requirements for all purposes considered are shown in Table 11.

Table 11. Area Requirements for Outdoor Activities

Dwelling Type	Area Per Dwelling Unit(sq. ft.)
Single-family	1,807
Two-family	1,500
Multi-family	800

Adding all of these areas together to find a total lot area involves a choice of dwelling type, density, and a mode of living. As an example, a single-family, three-bedroom house located in the central United States will be used. The areas that are required are given in Table 12.

Table 12. Lot Areas Required for Dwelling Structure and Outdoor Activities

Area Required for:	Area (Square Feet)
Dwelling structure	1575
Outdoor activities	
Recreation	1500
Service	600
Gardens	750
Total Lot Area	4425

CHAPTER III

TRENDS IN LOT SIZE CONTROLS

Public control of residential lot size is recognized as a necessity. There are two legal instruments available for this purpose. One of these is the zoning ordinance. It, however, has certain limitations to the achievement of desirable residential lot areas. The most obvious of these is that it is designed primarily for the control of the kinds of uses of land. It would be rare, indeed, to find a case where a zoning ordinance preceded the development of a city. Generally, a zoning ordinance is adopted only after land is developed to a point that someone or perhaps the whole community recognizes the error of permitting a continuation of development without control. At a time when blighting caused by mixed land use becomes evident, most of the land in the city is already platted and in the hands of individual owners as "lots of record".

Zoning Ordinances

Minimum lot areas and dimensions, as set out in zoning ordinances, are more accurately a measure of what existed in the community at the time the ordinance was adopted than a measure of what is desired by the community. These requirements, in effect, are what the public officials feel will be accepted in view of the lot sizes existing in the community. This is particularly true of the medium and high density zones, as defined in such ordinances. The estate, rural, or agricultural zones may more accurately reflect the desirable lot areas, since these zones are less likely to have been developed at the time of adoption of the zoning ordinance. A factor which affects the estate or rural district lot sizes, however, is the presence or absence of sanitary facilities and public water supply. Either consciously or unconsciously, public officials recognize this fact. In most cases, however, the control of sanitary requirements is incorporated in subdivision regulations.

The following is a report of a survey of 110 zoning ordinances. In choosing the ordinances, an attempt was made to select one ordinance from each of three cities in each state without regard to city size or location. The attempt was not entirely successful since the file of ordinances used was not complete. The first three ordinances filed alphabetically under each state were chosen when three or more were available. At least one city from each state is represented in the survey, with two from some and three from most states. The method of choosing the ordinances was somewhat arbitrary. No attempt was made to exclude any particular city from the survey. The ordinances were examined for information relating to lot area, width, front yards, side yards, and date of adoption. This information was recorded for the medium-density residential zone rather than low or high-density zones. In addition, the per-family lot requirement from the multi-family zones was recorded; also, lot area requirements were recorded from any zones designated as "rural", "agricultural", or "estate". The latter are usually the areas in which sanitary facilities are not provided.

Most of the ordinances were adopted or revised after the end of World War II, as is shown in Table 13.

Table 13. Dates of Adoption of 110 Zoning Ordinances of Cities in the 48 States of the United States.

Dates	Number of Ordinances	% of Total
Before 1946	23	20.8
1946	10	9.9
1947	11	10.0
1948	2	1.7
1949	4	3.6
1950	13	11.7
1951	14	12.7
1952	13	11.7
1953	14	12.7
1954	2	1.7
1955	1	0.9
Not Dated	3	2.6
Totals	110	100.0

Only 25 of the ordinances contained "estate", "agricultural", or "rural" districts. Of these, none made any mention of lot size in relation to the availability or absence of sanitary sewer facilities or public water mains. Those listing such districts are shown in Table 14, which shows their lot area requirements.

Table 14. Lot Areas Specified in Estate, Rural or Agricultural Districts in 110 Zoning Ordinances.

Lot Areas Specified (Sq. Ft.)	Number Times Specified	% of Total
Under 10,000	3	12.0
10,000	3	12.0
12,000	1	4.0
15,000	4	16.0
20,000	6	24.0
1/2 Acre	2	8.0
1 Acre or more	6	24.0
Totals	25*	100.0

*Only 25 of the ordinances specified districts of this type.

In this study, there appears to be a preference for lot areas of 15,000 square feet or more in estate districts. It should be recognized that there were not enough ordinances which made this specification to draw any firm conclusions. Of the 25, however, 18, or 72 per cent, required lots of 15,000 square feet or more. Of the six which required one "acre or more", five required one acre, and one, Eau Claire, Wisconsin, required an area of two acres. These requirements carry a suggestion of greater lot areas where no sanitary facilities exist, although none of these ordinances mentioned this condition in the definition of any of their districts.

In a separate survey of the zoning ordinances from 20 towns and urban counties that specified areas and lot dimensions for areas that were deficient in one or more of the public utilities, there was some indication of a preferred lot size. There were no sound reasons given for the size specified, however. The Prince George's County, Maryland Zoning Ordinance establishes a requirement of 10,000 square feet per lot where water is publicly supplied but where sewerage is not publicly provided; and 20,000 square feet where neither is available. In Virginia, the Arlington County Ordinance has identical requirements, but this ordinance also specifies that lot widths must average not less than 100 feet. A more recently adopted set of regulations for small towns is found in Kentucky where a majority of the zoning ordinances adopted in 1954 and 1955 require that the minimum lot area be 20,000 square feet in areas not served by public water and sewerage facilities. It appears that a standard of two families per gross acre where neither public water nor sewerage service is available and four families per gross acre where either one is provided is fairly widespread. There are some exceptions to these rules which show, among other things, the necessity of considering the problems of each individual community before adopting any legal standards of lot size. The zoning ordinances and subdivision regulations of these 20 cities and urban counties regulate open-country subdivisions with reference to sanitary standards. They show that in favorably situated sections, or perhaps in areas where excessive densities already existed at the time the ordinances were passed, lot sizes may range down to 5,000 square feet.

As stated earlier, the lot widths, areas, and building setbacks were recorded only from the "medium density" districts. These districts were chosen by taking the one so named in those ordinances that designated them by name, but where no such designation was given and three districts were used, the district that contained areas and dimensions between an upper and lower requirement was chosen. In cases where only two districts were used, the lower area and dimension requirements were taken. In the cities that had more than three residential districts, the requirement that came nearest the median value for all districts was recorded. The results are shown in Table 15.

Table 15. Lot Areas Required for Single-Family Houses in a Survey of 110 Zoning Ordinances.

Area Required Per Dwelling (Sq. Ft.)	Number Ordinances Specifying	% of Total
Under 3,000	7	6.8
3,000 thru 4,000	8	7.9
5,000	30	29.4
5,500	2	1.9
6,000	40	39.5
6,500	1	.9
7,000	1	.9
7,500	10	9.8
9,000	3	2.9
Totals	102*	100.0

*The eight ordinances not reflected in this table contained no area requirements.

It is apparent that the 5,000 and 6,000 square foot lot is predominant.

Lot area per-family, taken from the requirements for multi-family districts, was chosen or calculated from the specifications. Those cities that specified density in terms of families-per-acre were assumed to mean families-per-net-residential-acre, when such distinction was not made, and the areas were computed on that basis. One city specified that multi-family structures should provide lot area on the basis of square feet per-person rather than per-family. An average family of 3.6 persons was used to convert this figure to a per-family requirement. The results of the survey are given in Table 16.

Front-yard requirements were contained in a large percentage of the ordinances. These measurements were recorded for the same districts as the size of single family lots; that is, for the medium-density zones. The zone was selected by the method described for the lot area requirements earlier in this chapter. Front yard setbacks were given in some ordinances from the street right-of-way line, and in others from the center line of the street. Where the street center line distance was used, a 45 foot-wide street was assumed and calculations made to record the distance that such a measurement gave from the front property line. The distances shown in Table 17 are from the front property line.

Table 16. Lot Area Requirement Per-Family in Multi-Family Districts from a Survey of 110 Zoning Ordinances.

Lot Area Required Per Family in Multi-Family Zones (Sq. Ft.)	Number Ordinances Specifying	% of Total
Under 200	1	1.1
201 - 300	2	2.2
301 - 400	3	3.3
401 - 500	4	4.4
501 - 600	7	7.7
601 - 700	1	1.1
701 - 800	6	6.6
801 - 900	1	1.1
901 - 1000	16	17.5
1001 - 1200	1	1.1
1201 - 1300	4	4.4
1301 - 1500	12	13.2
1501 - 2000	11	12.1
2001 - 2500	11	12.1
2501 - 3000	5	5.5
3001 - 4000	4	4.4
4001 - 5000	2	2.2
Totals	91*	100.0

*The nineteen ordinances not reflected in this table contained no requirements for multi-family lot areas per family.

There is a strong emphasis on a 20 to 30 foot requirement. Eighty-four and three-tenths per cent of the ordinances contain such requirements. This agrees with the recommendations given by a majority of writers in the planning and housing fields. It must be recognized that these requirements apply principally to single-family structures. Although some of the ordinances specified front-yard setbacks for multi-family structures, the required setbacks were, in general, less than those given for single or two-family houses. In multi-

Table 17. Setback Requirements from a Survey of 110 Zoning Ordinances.

Setback Requirement (In Feet)	Number Ordinances Specifying	% of Total
5	1	1.0
10	3	2.8
15	11	10.0
20	26	25.0
25	42	40.2
30	20	19.1
35	2	1.9
Total	105*	100.0

*The five ordinances which are not reflected in this table contained no front setback requirements.

Table 18. Side-yard Requirements Found in a Survey of 110 Zoning Ordinances.

Side Yard Required (In Feet)	Number Ordinances Specifying	% of Total
3	10	9.3
4	7	6.5
5	37	34.8
6	13	12.5
7	9	8.4
8	12	10.5
10	13	12.5
12	3	2.8
15	2	1.8
Over 15	1	.9
Total	107*	100.0

*The three ordinances that are not reflected in this table gave side-yard requirements as a percentage of lot widths.

family districts, the front-yard setback was most often specified in terms of structure height. The formula used in these cases was a one foot setback for each one foot and sometimes two feet of structure height beyond a specified minimum of 5 to 10 feet.

Side-yards were specified in more ordinances than any other dimension. All but three of the 110 ordinances gave the actual minimum number of feet required for side yards. Those three contained side-yard requirements, but they were expressed as a percentage of lot width, which varied from 5 to 15 per cent. These three are not reflected in Table 18. Side-yard distances were also taken from the medium-density zones as described previously.

Only 58 of the 110 ordinances specified a minimum lot width. It may be assumed that such a large percentage of the land zoned for medium-density development is already platted and therefore consists of "lots of record" that the public officials feel it unnecessary to establish lot width minima which would have little or no application. It was noted that practically all ordinances set minimum lot widths in their low density or estate districts. These varied from 50 to 100 feet, with the largest percentage falling between 70 and 75 feet.

The number of ordinances specifying lot widths are shown in Table 19.

Table 19. Minimum Lot Widths for Medium Density Zones in 110 Zoning Ordinances.

Minimum Width (In Feet)	Number Ordinances Specifying	% of Total
40	2	3.4
45	5	8.5
50	25	43.2
60	17	29.4
65	2	3.4
70	1	1.7
75	3	5.2
80	3	5.2
Total	58*	100.0

*Only 58 of the ordinances gave specifications for lot widths.

The largest percentage of the ordinances required 50 foot widths. The next largest percentage required 60 feet.

There were very few ordinances that contained a specific width requirement for corner lots. A large part of the area requirement sections of the ordinances was devoted to requirements for setbacks and building area on corner lots. There appeared a wide variety of opinions as to the desirable difference in setback requirements from the "front" street and the "side" street on corner lots. Many of the ordinance specified that for a dwelling facing onto the "side" street, the same "front" yard requirement should be reserved as the "side" yard requirement of the corner structure.

Lot depth minima and maxima were conspicuously absent, for the most part, in the ordinances surveyed. No tabulation was made, because too few ordinances contained such restrictions, to make it possible to arrive at any general conclusion. Of the few ordinances that established dimensions for lot depths, none set a maximum. Minimum lot depth requirements range from 100 to 120 feet. There appears a reluctance among public officials to establish both width and depth minima when lot area requirements are given. The reason most often given by officials is that width and area requirements automatically establish depth requirements.

Residential lots that are excessively deep require longer cross or connecting streets and utility lines. In addition, there is a depth limit beyond which the occupant will not maintain the lot. Depths should be limited by ordinance to prevent the public from having to assume the cost of maintaining extra length of cross streets and utility lines, and to reduce the possibility of unmaintained areas at the rear of dwelling structures. The common concept of the residential lot as being a deep narrow plat of land is a carry-over from the lots platted along streams and lakes in the early settlement of this country. There is a trend towards a more shallow, but wider lot, particularly since the late 1930's, when the so-called "ranch house" rose in popularity. The restrictions on the amount of land the home owner can pay for and is willing to maintain has required that overall areas not be greatly increased, but that a wider lot be available to accommodate the broad-fronted ranch house. The general consensus appears to be that lot depths should be not less than 100 feet, but not greater than 200 feet except in estate districts.

Summary.--From this study of zoning ordinances from cities in all of the 48 states, the most that can be claimed is that the results express the public official's opinions of the lot sizes and dimensions that their citizens would accept. It is not felt that the size of the sample is sufficient to draw any general conclusions other than those mentioned. It might be well to recognize these results as "what's being done in other cities."

If it were assumed that a majority's choice as found in this survey is the correct one, the ideal residential lot would have the following characteristics as to area, width, depth, and setbacks:

Width	-	50 feet
Depth	-	100 feet
Area	-	6000 square feet
Front Yard	-	25 feet deep
Side Yards	-	5 feet on each side

Subdivision Regulations

Subdivision regulations are a set of rules and specifications adopted by a local legislative body for guidance of subdividers, land developers, and the general public. The purpose of the regulations is to insure that the process of subdividing raw land into urban lots will be done in a manner that is not contrary to public health, safety, and welfare. The regulations may serve to reserve for the public, adequate street rights-of-way, and community facilities, and to assure lots of an area, depth, and width that will guard against overcrowding, congestion, and other slum characteristics. The mere formulation and adoption of such controls will not in itself insure all of these objectives. The regulations should state in simple, clear terms the requirements that will best meet the needs of the community for which they are designed.

A study was made of the subdivision regulations of 117 political entities. All of the regulations were adopted after 1941. The findings of this study were compared with the findings of a similar study of the regulations of 284 urban places made by Harold W. Lautner in 1941.[81] The purpose of the comparison is to establish any trends that may be apparent in residential lot area, width and depth requirements.

In the analysis of land-subdivision regulations adopted since 1941, an attempt was made to choose regulations from cities of approximately the same population as those studied by Mr. Lautner. This effort was not entirely successful, however, because the file of regulations from which this study was made contained only 119 sets of regulations that were adopted since 1941. In reviewing the cities used by Lautner, it was noted that, by chance, the population groupings are quite similar. They appear to be sufficiently similar to warrant comparison.

Mr. Lautner's study included 167 cities which had minimum lot width requirements, while the present study contained only 88. In order to make a comparison it was necessary to reduce the numbers to percentages. Table 20 shows the lot width comparisons.

Table 20. Comparison of Minimum Residential Lot Widths of Two Periods: Pre-1941, and 1941 - 1955

Minimum Lot Widths (Ft.)	Number of Cities Compared			
	Pre-1941[82]		1941-1955	
	Number	% of Total	Number	% of Total
Below 40	19	11.3	2	2.3
40	64	38.3	6	6.8
50	69	41.1	54	61.3
60	10	6.0	23	26.2
75	3	1.8	1	1.1
Over 75	2	1.2	2	2.3
Totals	167	100.0	88	100.0

From Table 20 two trends are apparent, first, the preference for 60 foot wide lots increased over the preference for 50 foot lots very slightly. The preference for 50 foot lots increased 19.9 per cent, while the 60 foot lot increased 20.2 per cent. Secondly, the preference for lots over 75 feet wide increased 1.1 per cent. Another welcome trend appears with regard to lots below 40 feet in width. Regulations permitting lots below 40 feet in width decreased 9.0 per cent, while those permitting 40-foot lots also decreased by 31.5 per cent. A larger sample of regulations for the present study may have altered these trends to some degree. The percentage changes in preference would probably have been greater.

It may be concluded from this comparison that wider lots are coming into more general acceptance. The trend toward a 60 foot minimum may well be the result of the disproportionate demand for the so-called "ranch-type" house which cannot be built on the average 50 foot lot and still provide for required side yards.

The comparison of lot depths show a decided trend. The Lautner report shows 102 cities specifying lot depths, while the present study found 83 cities with such regulations. The information in Table 21 shows that every depth given, except one, declined in preference.

The percentage of cities requiring a 100 foot deep lot increased 11.0 per cent. The percentage of cities requiring other depths declined.

Both corner and interior lots must be considered in residential development. Mr. Lautner quotes Thomas Adams as saying:

> In the small-house subdivision the corner lots should be planned first. These lots should be wider and not so deep as other lots facing the same street, so as to secure a comparatively uniform width between the corner house and each of the two houses on the adjoining interior lots.[84]

A reasonable requirement to achieve this goal is to require corner lots to be as much wider than interior lots as the

Table 21. Comparision of Residential Lot Depths in Two Periods: Pre-1941, and 1941 - 1955

Minimum Lot Depths (Ft.)	Number of Cities Compared			
	Pre-1941[83]		1941-1955	
	Number	% of Total	Number	% of Total
Below 100	3	3.0	2	2.4
100	56	55.1	55	66.1
110	3	3.0	1	1.2
115	2	2.0	1	1.2
120	22	22.1	16	19.3
125	9	8.9	5	6.2
150	6	5.9	3	3.6
Totals	102	100.0	83	100.0

front yard requirement is deeper than the side yard requirement. This would mean that in a development that required a 25 foot front yard depth and a 10 foot side yard, the corner lots would have to be 15 feet wider than interior lots; or if the minimum interior lot width was 60 feet, the corner lot would have to be 75 feet wide. The depth of such lots could be as much smaller as the area requirement allowed. For instance if 6,000 square feet were required as a minimum area, the corner lot could be 75 feet wide by 80 feet deep. If this were required, the building space of the corner lot would be the area remaining after 25 feet was reserved for setbacks from each street, and a 10 foot setback from the adjoining interior lots; or a building area of 1,800 square feet. Such requirements would not leave an adequate building area unless the lot was at least 60 feet wide, and 6,000 square feet in area. In the case of a lot 50 feet wide and 5,000 square feet in area, the building space remaining would be only 840 square feet, which is below the minimum recommended floor space for single-family houses.

In the subdivision regulations surveyed in this study, all 117 cities set minimum lot areas. They ranged in size from 1,440 to 11,250 square feet. Mr. Lautner's study shows a range from 2,500 to 43,560 square feet. In order to compare the figures, it was necessary to eliminate those in Lautner's study with areas above 11,250 square feet, and choose the 100 cities which required areas less than this. Table 22 shows the comparisons of the lot area requirements in those 100 cities in Mr. Lautner's study and 117 cities in this study. There is a very apparent trend, in this comparison, of a preference for the 6,000 square foot lot. The earlier study showed a requirement of a minimum of 5,000 square feet in 48.0 per cent of the cities. The present study reveals that 40.5 per cent of the cities required a minimum of 6,000 square feet. In addition, the present study shows a substantial decline in all lot sizes below 6,000 square feet. Most encouraging of these trends is a 6.2 per cent reduction in the number of cities permitting lot sizes with areas less than 4,000 square feet.

Table 22. Comparison of Minimum Residential Lot Area Requirements of Two Periods: Pre 1941, and 1941 - 1955

Lot Area per lot (Sq. Ft.)	Number of Cities Compared			
	Pre-1941[85]		1941-1955	
	Number	% of Total	Number	% of Total
Below 4,000	9	9.0	3	2.8
4,000	16	16.0	4	3.4
4,500	3	3.0	1	0.8
5,000	48	48.0	41	34.2
6,000	14	14.0	47	40.5
7,000	3	3.0	5	4.4
7,500	4	4.0	9	7.8
8,000	0	0.0	1	0.8
9,000	0	0.0	3	2.8
10,000	2	2.0	2	1.7
11,250	1	1.0	1	0.8
Total	100	100.0	117	100.0

Conclusions.--This discussion and comparison bring out trends in requirements for lots of an increased size over those most popularly accepted before 1941. Lautner found that the minimum lot dimensions most commonly required were:

Width	50	feet, 41.4 per cent
Depth	100	feet, 55.1 per cent
Area	5,000	square feet, 48.0 per cent

Many of the regulations required widths of 40 feet. Mr. Lautner found that, at least, three-fourths of those regulations studied permitted no lot sizes below the fixed minima. However, he found that about half of them would allow variations where hardships indicated the necessity for such variations. In the present survey, 73.0 per cent of the cities allowed no variation that would reduce lot area; 44.2 per cent permitted variations to reduce widths; and only 12.6 per cent permitted variations that would reduce lot depths. There was no mention of maximum lot depths in the regulations during the period 1941 - 1955, except in relation to double frontage lots. The regulations of California cities most often contained maximum depth requirements. Most of the California cities set a minimum of a 200 foot depth for any lot that had double frontage.

The present study discloses that the minimum dimensions most commonly specified are:

Width	50 feet, 61.3 per cent
Depth	100 feet, 66.1 per cent
Area	6,000 square feet, 40.5 per cent

At first, this would appear an inconsistency, since the width times the depth does not equal the area. However, such a requirement is not inconsistent, since there is nothing to prevent an infinate number of combinations of widths and depths, either one of which may exceed the minimum. The larger area requirement might well help to educate the general public and to prevent them from relying too heavily on the minimum width and depth requirements as the only requirements. As an example of the application of the dimensions discovered to be most popular today, a specification that lots could be no less than 50 feet wide, 100 feet deep, nor less than 6,000 square feet in area could mean that for a particular area, 50 foot widths may be found satisfactory, and the area requirement dictates that the lots be 120 feet deep in order to obtain 6,000 square feet of area. Another area may be more adaptable to lots 60 feet wide and 100 feet deep to meet the minimum area requirement. Sixty-feet is certainly above the minimum width, but could improve the livability and appearance of the development.

Since these findings indicate the people's preferences as expressed in adopted regulations, they can be beneficial in the present inquiry of determining the recommended residential lot dimensions. People do not want to be too different from their neighbors -- even with relation to residential lot dimensions. In any community where it is desired to enact regulations controlling lot sizes, the people's preferences must be considered. In the absence of a known preference, the findings of this thesis could serve as a useful clue of what is both desirable and publicly acceptable. It is not proposed that this study nor any except one made in and for the community in question will or can suffice. Every community poses a separate problem with relation to lot dimensions, and there is no substitute for a thorough understanding of the particular problem of that community.

CHAPTER IV

FINDINGS AND RECOMMENDATIONS

In the process of establishing desirable residential lot dimensions, the most basic decision to be made is the choice of a dwelling type which the residential lot must accommodate. Planning and housing experts support the view that one-and two-family houses are generally the types preferred by families with growing children. Attitude opinion polls also indicate that people are more likely to be satisfied with their housing if it is low rise rather than high rise. Just how strong these feelings are, how they affect family life, and what forms the basis for these preferences are not made clear. The lack of private yard and garden space, however, appears to be the most often expressed fault of apartment dwellings, and even roof gardens or balconies cannot compensate for this lack. The problem of outdoor play supervision by mothers cannot easily be solved. Most planners appear to feel that this problem is an especially serious obstacle to normal family life in tall apartment buildings for families with children. This is not a condemnation of apartment dwelling units. There is a considerable proportion of the population who are members of childless families, or who have children of teen-age or adult level who prefer apartment dwellings. In addition, many families do not care for the responsibility of maintaining private yards, gardens, and open space. The range of residential lot sizes provided in a community should represent the needs of a normal cross-section of the population. According to the national population composition figures, approximately 50 per cent of the households are composed of elderly couples, childless couples, and households of two or more adults. These would, perhaps, choose walk-up or elevator apartments, while those families having small children would probably prefer one-, or two-family houses.

The ground area covered by a residential structure depends upon the gross floor area provided per family, the number of dwelling units and the height of the structure involved. It is generally agreed that per family gross floor area should be as shown in Table 2.

Light, air, amenities, and sound insulation distances require a greater open land area than a combination of all the other factors involved in the size of the residential lot. A lot that will meet both foundation area requirements and light, air, amenities, and sound insulation distances contains sufficient area for on-lot recreation, service, storage, access and gardening. A comparison of Table 9 and 12 shows that the functions just mentioned require an average of 4,425 square feet of lot area per family, while 6,105 square feet per family is required to meet the acceptable standards for light, air, amenities, sound insulation, and foundation area. A 6,105 square-foot-lot is a minimum, but the purpose of this thesis is to ascertain a desirable lot size not necessarily the minimum.

In addition to the factors mentioned above, land cost and present practice in public control measures have an added effect on what a desirable lot area should be. The lot most often specified closely approximates the area required to meet minimum requirements. However, larger and more desirable lots may be required at little or no additional cost.

Raw land generally costs around $1,000 an acre for new residential developments. At that cost, Fig. 1 shows that the cost of the 10,000, 12,000, and 20,000 square foot lots fall between the cost of those of 5,000 and 6,000 square feet. Five and ten thousand square foot lots cost approximately the same to develop, while the 6,000 square foot lot costs around $50 more per lot than these two. On land that costs less than $1,000 an acre, the 10,000 square foot lot actually costs less to develop than the other two mentioned, on the basis of the assumptions made in this thesis.

Site grading cost is considerably less on larger lots since there is a greater choice of structure location on the site. On relatively flat land, there would be little difference since the grading cost would be negligible.

The average family income in 1950 was $3,076 per year, of which $769 is normally considered available for shelter.

For that amount of money, shelter may be provided that costs $9,600 including land and structure, amortized over a 20-year period. Considering the developed lot cost at one-fifth of total shelter cost, the average family could afford a lot that cost up to $1,920. A 10,000 square foot lot is found in this thesis to cost around $1,640 to develop. This lot could be developed and offered for sale at a fair margin of profit at a price that is within the means of the average United States family.

Lot areas and dimensions depend on dwelling types, and the single-family houses require a porportionally greater per family area than the others. Table 23 gives what appears to be reasonably desirable per-family lot areas and dimensions.

Multi-family lot areas shown in Table 23 were determined by making assumptions as to the utilization of outdoor open space by multi-family structure dwellers. It is assumed that not more than 50 per cent of the families in any such structure will choose to use the 800 square feet of outdoor area per family at the same time. The net per-family lot area may thereby be reduced by 50 per cent of the outdoor activity areas which would be required for the total number of families on the lot. For example, a three-story structure containing ten dwelling units would require 8,000 square feet for outdoor activities. The minimum total per-family lot area was found in Table 12 to be 4,425 square feet. At this rate of lot per family, ten families would require 44,250 square feet.

This may be reduced by 50 per cent of the outdoor activity area, or 44,250 square feet less 4,000 square feet for a total lot area for a three-story structure containing ten dwelling units of 40,250 square feet. This figure was then rounded off to 40,000 square feet.

Table 23. Desirable Residential Lot Areas and Dimensions

Type of Residential Lot		Area in Square Feet	Width In Feet	Depth In Feet
Single-Family		10,000	80	125
Two-Family				
Units side-by-side		10,000	80	125
Units one above the other		10,000	80	125
Multi-Family				
Structure height	No. Dwelling units per Structure			
2 story	5 to 10	40,000	200	200
3 story	6 to 10	40,000	200	200
4 story	8 to 10	40,000	200	200
5 story	10 to 12	48,000	200	240
6 story	10 to 16	64,000	250	255
8 story	16 to 18	72,000	260	275

In addition to an area allotment per family, it is necessary to establish dimensions of the lot in terms of distances between structures, in order to assure usable open space. No multi-family structure in outlying residential areas should be allowed nearer another structure than the height of the taller of the two structures. This requirement will assure that the open spaces about structures are of such dimensions that they can be used for recreation, planting, and service approaches.

Writers on the subject of housing densities appear to agree that the only method of establishing a desirable degree of openness in group housing developments is to establish densities per gross development area and allowable distances between structures. Such developments may contain any combination of dwelling types, so as to make exact specifications impractical or even impossible. Urban densities recommended range from two to 200 families per gross acre, but there appears to be general agreement that group housing developments should contain from 10 to 30 families per gross acre. Such developments rarely contain structures more than three or four stories high, except in very large cities where elevator apartment developments may be built. There is a likelihood that group developments will contain a mixture of one-, two-, and multi-family structures. Assurance that the tall buildings will not rob light and air from the lower ones can be found in a height-distance ratio between structures. If the one-to-one ratio has any validity, it would appear that it would be as appropriate in this type development as in any other.

Since group developments do not normally conform to traditional street patterns, separate public controls should be adopted to cover this type of development. A reasonable land-area allowance for structures would appear to be one based on the type of structures in the development. Provision should be made for the same ratio of land per family as exists in the individual type developments as noted in Table 23.

Land, structures, and people are the ingredients of urbanization, and each bears a particular relation to the other and to the success or failure in securing desirable developments. Land must be apportioned in a manner which will provide each family with an adequate lot area for the conduct of all the functions connected with residence. Determination of a desirable lot area per family is not enough; the dimensions of the individual lots must be such that an appearance of congestion does not exist and sufficient area between structures is provided to allow the individual to maintain his feeling of personal dignity. The method for determining how much open space is required for these purposes is dependent upon a knowledge of the conditions in the community. A balance must be reached between providing an urban character with the correct mixture of rural spaciousness, and the amount of land people can and will maintain and at the same time an amount that they can afford. The method demonstrated in this thesis is applicable to any community. The techniques and standards recommended can prevent developement of slums on present open land or land in the process of being developed.

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